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Review on tractor mounted air assisted sprayer use in Indian agriculture

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Abstract

Tractor-mounted air-assisted sprayers have become an important tool in modern Indian agriculture for efficient and uniform application of pesticides and herbicides. Traditional methods, including manual and hydraulic sprayers, often result in uneven spray deposition, higher labour requirements, and excessive chemical use. Air-assisted sprayers employ an axial fan to atomize and transport spray droplets, achieving better canopy penetration, uniform droplet distribution, and reduced drift. This review synthesizes studies on nozzle types, air velocity, operating pressure, forward speed, and design innovations such as air deflectors, tapered sleeves, and electrostatic charging. Results indicate that these sprayers enhance spray efficiency, reduce chemical wastage, and lower labour and operational costs across crops such as mango, cashew, and horticultural plants. Tractor-mounted air-assisted sprayers are technically and economically superior to conventional sprayers, and their adoption in India can improve pesticide use efficiency and sustainability. Further field validation is recommended under diverse agro-climatic conditions.

Keywords: Tractor-mounted air-assisted sprayer, pesticide application, spray deposition, canopy penetration, sustainability etc

Introduction

India is predominantly an agriculture-based country, with approximately 75% of the population dependent on farming directly or indirectly. Farmers have traditionally used the same methods and equipment for seed sowing, spraying, and weeding. There is a need to develop effective spraying machines to improve productivity levels. Many Asian countries face high population pressures and low land productivity, and India is no exception. Agriculture plays a vital role in India's economy, engaging 54.6% of the population and contributing 17.4% to the country's Gross Value Added (2016-17). Although India is a major producer of mangoes, bananas, papaya, sapota, chillies, ginger, and okra, its productivity is far below countries like the USA, Turkey, Egypt, and South Africa. Poor pest and disease control is one of the main reasons for low yield, as insects and weeds cause significant crop losses.

Modern horticulture relies on insecticides, pesticides, and herbicides applied through sprayers. Spraying is an efficient technique for applying small volumes of protective chemicals, but conventional manually operated or power-operated hydraulic sprayers are time-consuming, labour-intensive, and often provide uneven coverage. Air-assisted sprayers address these limitations by using an air stream to atomize and transport droplets into the canopy, improving deposition and pest control. The axial fan generates high-speed airflow, allowing fine droplets to reach the target effectively. These sprayers are used for crops like mango, cashew, nutmeg, and nursery plants.

Over the past decade, air-assisted sprayers have shown remarkable improvements in design and operational efficiency, gaining acceptance among farmers and companies for crop enhancement. They operate via a tractor's power take-off shaft, pumping the chemical mixture through nozzles assisted by an axial fan to ensure uniform drift and penetration. Locally developed low-cost models are available and can be effective in orchards, but they require evaluation under local agro-climatic conditions to determine suitable operational parameters. The present review outlines the potential, benefits, and operational considerations of tractor-mounted air-assisted sprayers in Indian agriculture.

Materials and Methods

The air assisted sprayer uses a blower to produce air stream of sufficient discharge and velocity to carry the spray droplets to the target surface. Adequate velocity and pressure are needed to cause movement of leaves for under leaf deposition. Air stream guides the droplets to penetrate in the inner part of the plant canopy. This chapter deals with the work done by various researchers at national and international level, which were relevant to the present study

Singh *et al.*, (2006) ^[23] studied the characteristics of triple action, bi-action and hollow cone nozzles at operating pressures of 2.5, 3.0, 3.5 and 4.0 kg/cm². Better spray distribution was obtained with triple action and bi-action nozzles as compared to hollow cone nozzle for all the four pressures. The bi-action nozzle gave best results at the pressure of 3.5 kg/cm² with least coefficient of variation.

Ade and Rondelli (2007) ^[1] compared an air-assisted boom sprayer and a traditional boom sprayer. They found that in case of air-assisted sprayer the deposition on well-developed canopy was 18 per cent higher and had 37 per cent less losses to the ground when compared to a traditional sprayer without air-assistance.

Sehsah (2007) ^[20] studied the performance of an air assistance hydraulic sprayer fitted with two vertical adjustable air outlets in an apple field. For the study they selected three forward speeds (6, 9 and 12 km/h) and two different nozzles (Albus AVI 80015 and ATR 208). With the increase of forward speeds, the drift percentages decreased at all treatment conditions. The forward speed 12 km/h reduced the drift to 95.1 per-cent compared to forward speed of 6 km/h by using AVI 80015. The AVI 80015 nozzles gave the low values of deposit compared to the deposition values for ATR 208 nozzles.

Tekale *et al.*, (2007) ^[26] tested an air carrier sprayer equipped with an axial flow blower in an orange orchard. The sprayer was operated at 5, 10 and 15 bar pressures and 2, 3 and 4 km/h travel speeds. It was found that the tractor travel speed of 2 km/h and pressure 15 bar was better for the effective spraying.

Brown *et al.*, (2008) ^[2] compared a target-sensing spraying and conventional air-blast sprayer. The target-sensing sprayer achieved 41 per cent reduction in ground deposition compared with the conventional air-blast sprayer. Pesticide concentration in surface water runoff was reduced by 44 per cent with the target-sensing sprayer than the conventional application.

Marucco *et al.*, (2008) ^[13] operated an air-assisted sprayers for the application of pesticides in an orchard to achieve an even spray deposition within the canopy. Combinations of six different air velocities (3.7 to 23.0 m/s), four different forward speeds (3.9 to 13.0 km/h) and four different volume rates (200 to 1000 l/ha) were examined. It was found that at the forward speed of 7 km/h and an air velocity of 14 m/s uniform coverage was achieved, especially when low volumes (up to 400 l/ha) were sprayed.

Pergher and Petris (2008) ^[19] analysed the effects of different air flow rates on spray deposition in a Guyot-trained vineyard using a commercial air-assisted sprayer. The air flow rate treatments included: zero (fan off), 3.17 m³/s, 4.19 m³/s and 5.33 m³/s. Spray deposits were measured on both the upper and underside of leaves and on bunches using a water-soluble dye (Tartrazine) as a tracer. With the reduction of the air flow rate from 5.33 m³/s to 3.17 m³/s a significantly increase in overall mean deposition was observed. There was an increase of 67 per cent in deposits on the upper side of leaf but on the underside, deposits were similar.

Shahare *et al.*, (2010) ^[21] developed an air sleeve boom sprayer

which could be operated by a 30-35 hp tractor. For this the axial flow blower was developed with a capacity of 3.1 m³/s. The sleeve performance was evaluated for different sleeve angles, viz -15°, 0°, 15° and 30° and for nozzle angles of 25°, 35° and 45°. The droplet density increased with increase in air sleeve angle. Better values of VMD were obtained with 30° sleeve angle and 35° nozzle angles.

Singh *et al.*, (2010) ^[22] developed a tractor mounted air-assisted sprayer and compared with the conventional tractor mounted sprayer. They found that at the forward speed of 74.0 km/h the uniformity coefficient of droplets for the air-assisted sprayer was better (1.69) than for conventional sprayer (2.04). The sprayer was able to put an effective number of drops per square centimetre area on the underside of leaves at any section of the plants due to air assistance.

Guler *et al.*, (2011) ^[7] studied the effect of a prototype air deflector and spraying unit hanged on conventional air-assisted orchard sprayer when operated at the pressures of 6, 12 and 18 bar and air flow rates of 24830, 30473 and 36117 m³/h. Treatment with air deflector and spraying unit at 6 bar pressure and 30473 m³/h air flow rate produced the most uniform distribution (CV = 6.24 per cent). The sprayer with air deflector and spraying unit produced better deposits, coverage and canopy distribution uniformity than the conventional air-assisted sprayer. The conventional air-assisted sprayer produced higher ground sedimentation and airborne drift than the treatment with air deflector and spraying unit at 6 bar pressure and 30473 m³/h air flow rate conditions.

Sukumaran *et al.*, (2012) ^[25] studied the effect of pressure on discharge rate and wear of hollow cone nozzles having nozzle tip materials such as brass, plastic and stainless steel. Discharge rate of nozzles increased with the increase of pressure and usage of the nozzle. Average orifice hole diameter of all type of nozzle materials increased with increase in pressure and usage. The stainless steel was found to be the better material in comparison of plastic and brass.

Wandkar *et al.*, (2013) ^[27] developed air assisted sprayer for greenhouse floriculture crops. A tapered air sleeve was designed and made with fibre reinforced PVC material in order to get uniform air velocity at each outlet. The performance of developed sprayer was evaluated in the laboratory to study the effect of different air velocity (9, 12, 16 and 20 m/s) and pump discharge (2.5, 4.5, 7 and 9 l/min) levels on droplets size, droplet density and uniformity coefficient at six different points of artificial plant canopy. The optimum result of droplet size (100-150 µm), droplet density (25-35 droplets per m²) and uniformity coefficient (near unity) at all point positions were observed for air velocity of 20 m/s and pump discharge of 2.5 l/min.

Hassen *et al.*, (2013) ^[8] studied the effect of nozzle type, angle and pressure on spray volumetric distribution of broadcasting and banding application. Study was conducted on a spray patternator using even flat fan nozzle for banding application and standard flat fan nozzle for broadcasting application. The combination of even flat nozzle, nozzle angle 80° and nozzle pressure 300 kPa gave the best spray volumetric distribution and minimum coefficient of variations 42.73 per cent. Even flat fan nozzle provided spray volumetric distribution better than standard flat fan nozzle.

Khot *et al.*, (2014) ^[11] compared a retrofit air-assisted sprayer, a conventional axial fan air blast sprayer and a multi fan vertical air-blast sprayer for their application efficiency in citrus orchards. The deposition and coverage on the canopy surface were higher than at 0.6 m inside the canopy for all sprayers. The retrofit sprayer resulted in 30 per cents less spray volume

deposition in one medium size canopy and 70 per cent less spray volume deposition in short size canopy in comparison to the other two sprayers. The multi fan vertical sprayer resulted in significantly less deposition and coverage for the lower sections of short canopies and for 0.6 m inside tall canopies.

Mishra *et al.*, (2014) ^[16] evaluated the performance of aero blast sprayer. They were found that due to charging of droplets by the charged twin nozzle the droplet density, area covered by droplets, volume of spray deposition, uniformity coefficient and droplet size on the upper and under sides of leaves was significantly higher than the uncharged twin nozzle. Similar result was obtained in case of single nozzle also.

Gholap *et al.*, (2015) ^[6] studied two 12-meter tractor operated boom type field sprayers of the ASPEE make one of the existing designs and other of newly developed design having similar specifications were selected for the study. Comparative performance showed that the liquid distribution under the developed boom sprayer improved, the mean discharge and pressure of developed boom sprayer increased by 49 per cent and 184.4 per cent, respectively.

Narang *et al.*, (2015) ^[17] evaluated an air-assisted orchard sprayer in Indian gooseberry and kinnow orchard. They reported that there was a saving in labour and saving in cost of spraying by 91.2 per cent and 64.08 per cent respectively as compared to tractor operated gun type sprayer.

Karale *et al.*, (2016) ^[10] evaluated a twin and a single nozzle of an electrostatic sprayer.

The field performance of aero blast sprayer was carried out for the pigeon pea crop field. The average effective field capacity of the aero blast sprayer was found to be 2.5 ha/h. The fuel consumption of the tractor for the aero blast sprayer was found to be 2.5 l/h. The cost of operation of the machine was calculated and found to be 250 Rs/ha and 125 Rs/ha.

Wandkar *et al.*, (2017) ^[27] evaluated that the sprayer was operated at three forward speeds (2, 3 and 4 km/h) with four air velocity levels (20, 25, 30 and 35 m/s) and two different types of nozzles (hollow cone and flat pan nozzle). He was observed that spray deposition significantly increases with increase in air velocity and hollow cone nozzle able to deposit more amount of spray as compared to flat cone nozzle. The maximum spray was deposited on upper leaf surface and uniform spray deposition was observed at air velocity of 35 m/s with hollow cone nozzle.

Kadam *et al.*, (2022) ^[9] evaluated a tractor-operated aero-blast sprayer in a guava orchard and found higher droplet density and deposition at the upper canopy, with a field capacity of 1.60–2.03 ha h⁻¹, 80% efficiency, and fuel use of 5.30–5.60 L h⁻¹, highlighting its advantages for uniform spraying and reduced labour.

Pandiselvam *et al.*, (2023) ^[18] tested a tractor-mounted air blast sprayer for tall coconut trees and determined that 1.5 km h⁻¹ tractor speed and 3000 rpm blower speed gave optimal droplet size (124 µm) and deposition (7.2 µL cm⁻²) with field capacity 0.524 ha h⁻¹, 73.72% efficiency, and 4.67 L h⁻¹ fuel use. Lipiński *et al.* (2025) ^[12] showed that air-assisted spraying in cereal crops reduced pesticide drift by 40.7% in coverage and 37.6% in droplet density, reaching 80% reduction at 6 km h⁻¹, demonstrating improved efficiency and environmental safety.

Lipinski *et al.*, (2025) evaluated air-assisted spraying in cereal crops and found it reduced pesticide drift by 40.7% in coverage and 37.6% in droplet density, with up to 50% reduction 1 m from the sprayed area. At a sprayer speed of 6 km/h, drift was cut by 80%, showing that air-assisted spraying can enhance application efficiency while reducing environmental impact.

Conclusion

Tractor-mounted air-assisted sprayers offer clear advantages over conventional sprayers by ensuring better spray deposition, canopy penetration, and droplet uniformity while reducing drift and chemical losses. Their efficiency depends on optimized nozzle type, air velocity, forward speed, and operating pressure, with design improvements like air deflectors and electrostatic charging further enhancing performance. Alongside technical benefits, they also provide substantial labour and cost savings, making them highly suitable for Indian orchards and plantation crops. Wider adoption, supported by region-specific field validation, can significantly improve pesticide use efficiency and sustainability in Indian agriculture.

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